

**ELEVATOR DESIGN FOR THE 21ST CENTURY:  
DESIGN CRITERIA FOR ELEVATORS WHEN  
USED AS THE PRIMARY MEANS OF  
EVACUATION DURING FIRE EMERGENCIES\***

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**ABSTRACT**

The elevator for use in the 21st century must be designed for safety under all conditions that may be expected **in** the building in which they are to be installed. The integration of smoke control systems and fire protection systems along with evacuation procedures for the use of elevators systems during fire emergencies are discussed. **A** total approach for the safe use of elevators for occupant evacuation during fire emergencies is examined, and recommendations are made to bring elevator systems **to** a level of safety that can permit their **use** during fire emergencies. It is suggested that by introducing a number of existing and practical safety measures, elevators can become the primary means of egress, as well as the primary means of ingress to a building.

Elevators transport more people, and **do** this with a safety record that surpasses any other means of transportation. The utilization of today's high-rise buildings **is feasible** only **because** modern, fast moving, reliable elevators permit access to and egress from upper stories. Persons who are physically limited, in particular, require the use of elevators for access to stories above the ground floor. It is essential that **the elevator** industry provide elevators that are as safe for evacuation during a fire emergency as they are for normal entry. But one might also ask why only for the physically limited? Shouldn't everyone be provided with safe

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means of egress, National Institute of Standards and Technology studies indicate that high-rise buildings can be completely evacuated **40** percent faster using properly programmed elevators, than by using stairs.

### CRITERIA FOR SAFE ELEVATOR DESIGN

The following is a list of proposed requirements to assure elevator safety during fire emergencies. **It is** not all inclusive or in any order of priority. Nor is it a pick and choose list of options. Rather it **is** intended as a compendium of safeguards that must be included in a total approach to the design of elevator systems that can be safely utilized for evacuation during a fire emergency, and that can enhance fire fighting operations, reduce costly fire damage to the elevators, and diminish the time that businesses located in the building must endure interruption to their normal routines. Additional studies will be required to insure that all potential events have been considered.

1. The building should be fully protected by a sprinkler system.
2. Elevator shafts should be pressurized.
3. Elevator lobbies on all floors should be enclosed.
4. Elevator lobbies should be pressurized.
5. Air intakes for the elevator shaft and lobby pressurization systems should be from a smoke free location.
6. All elevator lobbies should be protected by smoke detectors.
7. Elevator systems should be made resistive to water.
8. When a power failure **occurs**, all elevators should return to their designated level.
9. All elevators should be capable of being operated from a dedicated emergency power generator.
10. All elevator lobbies should have access to a pressurized stairway without passing through another fire area.
11. All elevator cars should have means for two way voice communication between the elevator car and the fire command station.
12. All elevator lobbies should have means for two way voice communication between the elevator lobby and the fire command station.
13. A program for the priority of elevator response during fire emergencies should be developed.

### WARRANTS AND JUSTIFICATION FOR CRITERIA

#### 1. The Building Should Be Fully Protected by a Sprinkler System

Sprinklers have proven to be the best means of preventing small fires from becoming big fires and sprinklers are also the best smoke control system available.

To moderate the danger to persons using elevators during the occurrence of a fire in a building, the building must be sprinklered throughout in accordance with “NFPA 13 Standard for the Installation of Sprinkler Systems.” This is a prime requisite and any attempt to circumvent “or trade off” this provision should be resisted. Elevator machine rooms and the bottom of all elevator shafts shall be sprinklered. The shaft of passenger elevators need not be sprinklered, but the shaft of freight elevators should contain sprinklers.

## 2. Elevator Shafts Should Be Pressurized

Elevator shafts, as a result of “stack effect” in a high-rise buildings, are usually the area of lowest pressure on a floor. In the event of a fire, the tendency is for smoke and heat to flow towards and up elevator shafts. In the elevator shaft was pressurized to .05 inches of water (12 Pa), it would no longer be the low pressure area on the floor and smoke and heat would no longer migrate into the elevator shaft.

Most jurisdictions require that elevator shafts be provided with means of venting smoke and hot gases to the outer air. This vent area is required to be 3.5 percent of the total shaft area or at least 3 square feet per elevator car, whichever is greatest. A variance for this requirement can usually be obtained in such an instance. The variance should provide that elevator shaft vents may be maintained closed as long as provisions to open them during a fire, if necessary. Controls for this purpose should be located at the Fire Command Station in the lobby. This is an area where existing codes should be changed to permit application of advances in smoke control in which air flow is controlled. The closing of these elevator vents would permit the elevator shaft to be pressurized and prevent the flow of smoke and heat into the elevator shafts during a fire.

Pressurizing elevator shafts brings additional benefits. Some of these are:

1. As in stair pressurization, the constant and critical need of the fire service to gain the use of an elevator shaft that is smoke-tight is achieved. All openings between the shaft and the rest of the building must be sealed in order to obtain the pressure differential necessary to assure a smoke-tight elevator shaft.
2. By closing the elevator shaft vents, the shaft will no longer be a conduit through which heat is wasted during the heating season and cool air is lost during the time when air-conditioning is required. This could result in a significant reduction of costs and conserve energy as well.
3. During cold and windy days, the opening and closing of the shaftway and elevator car doors will be achieved with much less strain and wear on door operating motors. Maintenance costs are thereby reduced and down time is lessened.

### 3. All Elevator Lobbies Should Be Enclosed

Elevator lobbies on all floors should be enclosed with at least 2 hours rated partitions. The doorways in these partitions should be protected by at least 1½ hour rated door assemblies. The doors in these partitions may be maintained in the open position, provided they close automatically when an alarm of fire is received in the building from any source. Freight elevators should not be permitted in the same enclosure with passenger elevators.

The reason for these enclosed lobbies is to provide an area of refuge for building occupants, while awaiting elevators. This space will also provide a fire-protected area between the elevator shaft and the rest of the floor.

Enclosure requirements on the lobby or street floor may be omitted provided one of the following conditions is met:

1. The floor is fully sprinklered.
2. The fire load on this floor is limited.
3. Any area on this floor where a fire load might exist is separated from the elevator lobby by a 2-hour rated partition. Any openings in this partition should be provided with 1½-hour rated enclosures. Openings in enclosures should be protected by self-closing devices maintained in the closed position. No devices should be permitted to hold these doors in the open position.

### 4. All Elevator Lobbies Should Be Pressurized

The elevator lobbies on all floors should be pressurized to a pressure differential of at least .05 inches of water (12 Pa) with respect to the adjacent compartments. This will prevent the entry of smoke into the elevator lobby and thus provide the building occupants with an area of refuge while awaiting elevators. This measure will also assist in pressurizing the elevator shafts and preclude the need for gasketing of the shaft-way doors, as would be needed if an attempt is made to pressurize the elevator shaft only. Pressurization of elevator lobbies will also supply building occupants with an ample supply of fresh, breathable air while awaiting elevators during a fire emergency.

Meeting the need to have an air-tight seal between the elevator lobby and the rest of the floor in order to obtain the necessary pressure differential will also help to ensure that all openings in the partitions are properly sealed and thus prevent the entry of smoke into the elevator lobby. The enclosed lobby will also assist in the retention of conditioned air in occupied portions of the building, thus reducing costs and conserving energy.

### **5. Air Intake for the Elevator Shaft and Lobby Pressurization Systems Should Be from a Smoke-Free Location**

Location of air intakes for elevator shaft and elevator lobby pressurization systems must be as smoke-free as possible under fire conditions. Roof and upper level locations are generally problematic since smoke from a fire in a building will rise under most conditions and the roof and upper levels will most likely be contaminated with smoke early in the fire. To locate air intakes at these locations is usually not acceptable. It should be noted in the same context that protection of these intakes by smoke detectors has also not proven satisfactory since these devices are not reliable during cold weather and when they do function the pressurization system is lost.

It is advisable to locate these intakes as remote from the building as possible where buildings are built in a campus-like setting. Where this is impossible, they should be located as low in the building as possible. Considering the design of most high-rise buildings in major city environments, the second floor is probably the most likely place for their location. This is also the usual location of air inlets for lobby and below-ground HVAC systems. The least desirable location for the air inlets is at the roof. If this location must be used, then the prevailing wind direction must be considered. Intakes should be provided on both the lee and windward sides. Provisions should be made so that the smoke free side will be selected at the time of a fire.

### **6. All Elevator Lobbies Should Be Protected by Smoke Detectors**

Smoke detectors in elevator lobbies are required where elevators are to be used to evacuate building occupants during a fire. This is to prevent the elevator from stopping on any floor where the elevator lobby may have become contaminated with smoke. Phase-I (Recall) could be replaced with evacuation programming as outlined in item 13, p. 346.

### **7. The Elevators Systems Should Be Made Resistive to Water**

Because of the adverse effect that water has upon the safe and reliable operation of an elevator, it is imperative that elevators be made resistive to water. It is not expected that elevators be made to operate under water, but much can be done to reduce the present vulnerability of elevator systems to the presence of relatively small amounts of water. Water in an elevator shaft can enter controls and other electronic devices causing elevators to operate in an erratic and unsafe manner. **As** more and more buildings are fully sprinklered the potential for elevator failure due to water intrusion will become greater. If elevators can be designed to operate on the exterior of buildings exposed to the elements, it is not beyond current design

capabilities to have elevators within buildings operate safely when foreseeable amounts of water enters the elevator shaft.

In addition to preventing water from entering elevator shafts, precautions should be taken to contain any water that does enter the shaft. The entire electrical control system of elevators, including door interlocks, door protective devices, motors, brakes, drives, door operating devices, door controllers, cabinets, junction boxes in hoist-way and on cars, conduits, limit switches, safety switches, floor selection and leveling systems, all signal fixtures, car lights, outlets etc. should be National Electrical Manufacturing Association (NEMA) 4 rated or of NEMA 4 type approved design. Travelling cables should be of a type approved for outdoor use in wet environments.

The elevator car should be designed to deflect falling water away from door openings. The roof of the car should be designed to prevent pooling or collection of water. The car should be sealed to prevent water from entering through panel joints, lights, fan, vents, or emergency exits. Sprinklers located in elevator lobbies should be the type that turn off when the temperature is reduced. The floors of elevator lobbies should be graded, with the grade sloping away from the elevator shafts.

#### **8. If a Power Failure Occurs, All Elevators Should Automatically Return to the Designated Level**

All elevators used to evacuate building occupants during a fire shall return to the designated level in the event of a power failure. Precautions must be taken to prevent building occupants from becoming trapped due to a power failure during a fire. A failure of electrical power during a fire in a building is a foreseeable event and as such requires planning before the event. It is within the state of the art technology to design elevators that will have a low probability of trapping occupants when a power failure occurs. This should be accomplished without using emergency power generators. One available method is the use of a battery back-up system. With proper safeguards, this provision can also be extended to other elevator failures.

#### **9. All Elevators Should Be Capable of Being Operated by a Dedicated Emergency Power Generator**

All elevators that are to be used for the evacuation of building occupants during a fire shall be capable of being operated by a dedicated emergency power generator. This generator should be located on the same floor and as close to the elevator machinery room as possible. It shall also be sufficient to simultaneously operate all elevator mechanisms located on this floor. Every floor should have its own dedicated emergency power generator that shall not be connected to any other electrical system in the building. The electrical power supply cables between

the emergency power generator and the elevator machinery should be as short as possible and should be installed so as to be protected from thermal and mechanical damage. The capacity of the fuel supply for the emergency generator should be capable of supplying the total emergency power load for at least six hours.

This configuration of elevator emergency power will help to ensure the operation of the elevators for evacuations when **all** other electrical systems in the building fail. If one bank of elevators fail, all other elevator **banks should** continue to operate.

#### **10. All Elevator Lobbies Should Have Direct Access to a Pressurized Fire Stair without Passing through Another Fire Area**

Building occupants awaiting an evacuation elevator in an elevator lobby of an upper floor shall have direct access to a pressurized fire stair. This is to provide a means of egress if the evacuation elevator fails to respond to their floor. Occupants in the elevator lobby should not be required to pass through a fire area to gain access to a means of egress. Fire stairs must be safely accessible from elevator lobbies.

#### **11. All Elevator Cars Should Have a Means for Two-way Voice Communication between the Elevator Car and the Fire Command Station**

Occupants of elevators should have the capability of communicating via voice communication between their elevator car and the Fire Command Station. This provision is necessary in case of elevator car failure, so that the occupants would then be able to communicate to operating personnel at the Fire Command Station. Necessary action to alleviate their situation can then be taken.

#### **12. All Upper Floor Elevator Lobbies Should Have a Means for Two-way Voice Communication between the Elevator Lobby and the Fire Command Station**

Building occupants should have the ability to communicate via voice communications between their elevator lobby and the Fire Command Station. This provision is necessary so that occupants of any elevator lobby may transmit any problems they may encounter to the operating personnel at the Fire Command Station.

### 13. A Program for Priority o Elevator Response during Fire Emergencies Should Be Developed

Principles that should be followed in developing a program for the sequencing of elevators for occupant evacuation are: Evacuate those occupants that are exposed to the greatest hazard FIRST, then continue to remove those who may become exposed next, then remove the least exposed last. The following **is** an example of this procedure:

1. The fire floor is evacuated first.
2. All elevators in the bank that serves the fire floor respond first to the fire floor.
3. Every floor should have sufficient elevators serving that floor to evacuate all occupants in three minutes.
4. If elevator banks are limited to fifteen floors, the entire building should be evacuated in forty-five minutes.
5. The floor above the fire should be evacuated directly after the fire floor.
6. The floors above should then be progressively evacuated.
7. Elevators in banks above the fire floor, but not serving the fire floor, should start at the bottom of their bank and progressively evacuate the floors above.
8. Sensors to predict the number of persons waiting are recommended.
9. Visual displays on all floors showing the location of all elevators are recommended.
10. Elevator call buttons should be inoperative.
11. Floor selector buttons in the car should be inoperative.

## CONCLUSION

**The** time has come for the elevator industry to take the initiative and begin the work required to take the industry into the **21st** century, by designing elevators that cannot only provide safe reliable access to the upper stories of high-rise buildings but can also provide safe reliable egress from these **same** buildings under fire emergency conditions. If manufacturers fail to take such initiative they will undoubtedly be inundated with code requirements from many different groups, demanding improvements that the industry will find very difficult to meet compliance. It is time for the eradication of all those signs found in elevator lobbies that are derogatory to the elevator industry that read: "IN **CASE OF FIRE, USE THE STAIRS.**" These signs should be replaced with signs which read "IN CASE OF FIRE, **USE THE ELEVATORS.**"



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